

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 22 August 1997		3. REPORT TYPE AND DATES COVERED Final Technical Report 1 jun 94 to 31 May 97
4. TITLE AND SUBTITLE Behavior of Multiphase Granular Media: Modeling the Static-to-Viscous Flow Regime			5. FUNDING NUMBERS F496920-94-1-0320  AFOSRTR 970400	
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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFOSR/NA 110 Duncan Ave, Suite B 115 Bolling AFB, DC 20332-8050			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) In the researched work, assemblages of nearly perfectly round photoelastic disks were subjected to confined compression, then sheared along an interface of varying roughness (very rough or very smooth). Overall, there was excellent comparison between the behavior observed in the physical system and the DEM simulations. Global response as measured by external wall forces, and individual particle kinematics were found to be in excellent agreement. Local contact forces and interactions were modeled generally well, but not as well as the global behavior.				
14. SUBJECT TERMS			15. NUMBER OF PAGES 6	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

22 AUG 1997



## FINAL TECHNICAL REPORT

June 1, 1996 to May 31, 1997

### Behavior of Multiphase Granular Media: Modeling the Static-to-Viscous Flow Regime

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The original thrust of the research in this AASERT grant was to investigate the solidification of dense fluid suspensions by using Discrete Element Method (DEM) simulations. With the changing emphasis within the Particulate Mechanics task in AFOSR, it was decided in January 1996 after consultation and approval from the Interim Program Manager to modify the objectives in the AASERT research. The new thrust involved making extremely careful and controlled comparisons between our DEM analyses and physical interface shear tests data on photoelastic rods conducted by S.G. Paikowsky *et al* as part of their AFOSR-funded research.

In Paikowsky's work, assemblages of nearly perfectly round photoelastic disks were subjected to confined compression, then sheared along an interface of varying roughness (very rough or very smooth). Overall, there was excellent comparison between the behavior observed in the physical system and the DEM simulations. Global response as measured by external wall forces, and individual particle kinematics were found to be in excellent agreement. Local contact forces and interactions were modeled generally well, but not as well as the global behavior.

The details of whether an assemblage is modeled as an assemblage of completely uniform-sized particles, or an assemblage with very slight size variations was found to be a crucial factor in the level of agreement between the physical and numerical systems. In general, even minute variations in particle size can significantly alter the local contact behavior in the DEM simulations. By using a gradation of particle sizes matching the actual observed particle gradation, generally excellent comparisons were made. While it was intended that tests using particles of round as well as ellipse shapes would be compared, the results from the physical tests composed of ellipse shapes were not provided to us.

One US citizen graduate student (Gregory Mischel) was fully supported during his graduate career from this AASERT grant (he received full tuition waivers from UMass Lowell during each semester here, a non-required part of our cost-sharing effort). This student has completed his coursework requirements, is currently finishing his thesis, and should graduate by early fall. As well, one US citizen undergraduate student (Apryl Wilson) was supported for one month this spring on this contract. The grades for both students are satisfactory.

In addition to the research summarized above, Gregory Mischel also participated in a major international collaborative research effort on pressures within silos filled with granular materials, spearheaded by the University of Edinburgh and the UK Engineering and Physical Sciences Research Council. In this *pro bono* collaboration, simulations of silo filling and discharging were conducted using round and ellipse-shaped particles, for comparison with other DEM and Finite Element analyses. These results will be fully documented in Mischel's thesis.

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